Notes on the Habits and Life History of *Sciara molokaiensis* Grimshaw, a Serious Pest of the Roots of Plants in Hawaii (Mycetophylidae).

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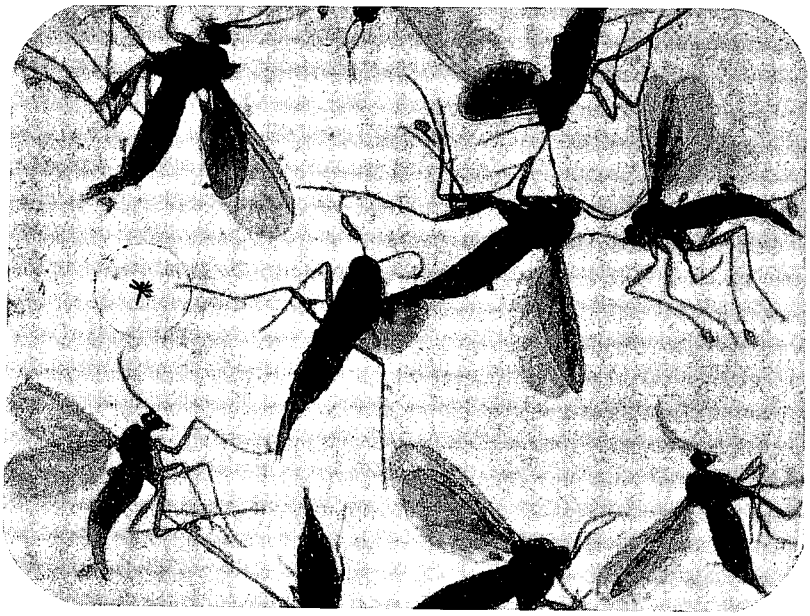
For several years I have been making notes on the habits of these troublesome little flies. They are commonly called Fungus Gnats, because of their well-known habit of breeding in mushrooms. It is their relation to the higher plants, however, that has brought them forcibly to my attention. The larvae live in the soil and under certain weather conditions are very destructive to living roots.

In April, 1926, while growing pineapple plants in root cages in our greenhouses at the University, I discovered that root tips were being eaten out by the larvae of these flies. Further search showed that this pest occurred throughout the pineapple-growing sections. It was easy to see the damage that the larvae do to newly-set plants. By pulling up plants that have failed, it is not uncommon to find clusters of the "worms" congregated on the end of the cut surface. In that position they are ready to devour the ends of the new roots as fast as they push out. Rots then cause the death of the whole plant.

Looking up the literature on the subject, I found that these insects have been recorded attacking the roots of wheat, corn, clover, alfalfa, grasses, cucumber, lettuce, carnations and plants in greenhouses. They also injure potatoes, causing a scabby appearance, breed in tulip bulbs, and even are recorded as infesting such fruits as the apple.

Hence it is not surprising to find these flies attracted by the tissues of pineapple plants. Undoubtedly they do far greater injury than any of us heretofore have suspected. Naturally it is very easy to overlook such tiny creatures, especially under field conditions. Yet it is not difficult to see the gnat-like flies, especially on a quiet sunny morning as they swarm about the

plants. Then, following this up by observations on what is taking place underground, using the root cages, we see the devastation caused by the maggots.



Mycetophylid flies, magnified about 10 times. The small figure at the left, in the circle, is about natural size. In this state the insects are seen hovering about the plants and entering the soil to lay their eggs.

HABITS AND LIFE HISTORY

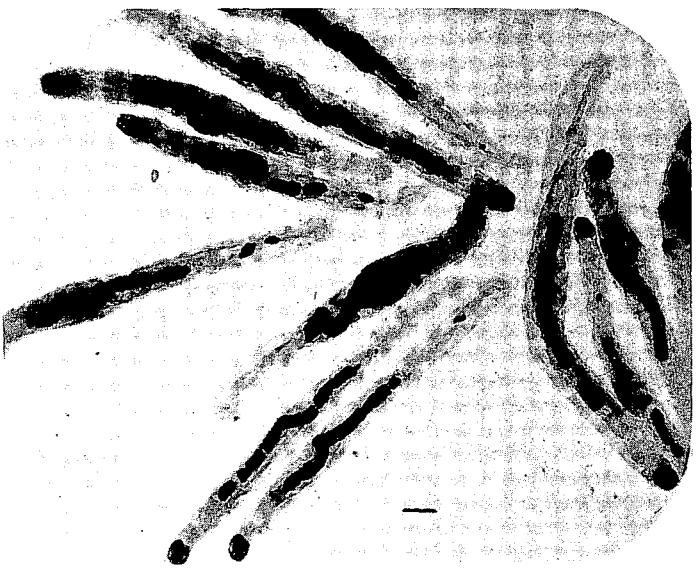
The best papers treating on these subjects deal with species affecting house plants * and mushrooms.** In the latter paper the female fly is said to be able to produce 1000 eggs. These require only three days to hatch, the larvae feed for seven days and pupate, the adult flies emerge four days later. Thus it will be observed that under mushroom house conditions the whole life period from egg to egg again is only fourteen days. I have

* Journ. Econ. Ent. vol. 9, pp. 538-49.

** U. S. Dept. Agric., Farmers' Bull. No. 789.

estimated, rather roughly, the time required here to be about twenty-four to thirty days.

In one instance I found a fly in the root cage had gone down into the soil a depth of six inches, depositing her eggs against the glass, where they were all in plain view. These were arranged in five bunches, placed in a sort of circle, about one inch in diameter. The dead body of the mother fly was in the center.



Larvae of mycetophylid flies, magnified about 12 diameters, The small black line below is about their natural size when full grown. These maggots are found in any plant refuse when it is decomposing. In the soil they feed on the root hairs and root tips causing the destruction of living plants.

Each of the bunches had approximately twenty eggs, so evidently this female had died when she finished laying about one hundred eggs—possibly she had deposited others elsewhere. The individual eggs were oval in appearance and yellowish in color; the clusters being quite easily visible to the naked eye.

After six days the larvae hatched and made their first meal on the eggshells. They then began to devour the body of their mother. The following day they had increased wonderfully in

size and had moved in a mass to young roots about three inches away. Every root tip was eaten out and the larvae were browsing on the root hairs. Feeding for a period of twelve days on all the roots within a radius of about six inches, the larvae appeared to be fully grown. They began their movement toward the surface, forming a continuous line single file. I watched them spinning flimsy silken walls to hold the particles of soil in the cavities where they pupated. Six days later the flies emerged. Hence the whole life cycle was accomplished in twenty-four days.

During emergence under normal conditions, the pupae work their way to the surface of the soil. It is interesting to see the flies emerge. I watched one come out of its pupal skin: At first it slid out very slowly, and I thought I would see the process of expanding the wings, which is a common procedure among flies. To my surprise, however, he ran away so fast that I lost my sight of him entirely. He shot out of the empty pupa skin like a young pheasant just out of the egg. I have never seen any other creature to equal it for precociousness.

As indicated above, the larvae of these flies are omnivorous feeders. I have found that the flies congregate around piles of semi-decomposed manure. The maggots occur in this material in writhing masses all clustered together. Again, we usually find them abundantly in old pineapple stumps in our fields, and they even show a great preference for the decomposing fruits. In field practice these waste products are commonly pushed out of sight under the plants. Here the pests breed in such countless numbers that they become a real menace to the growing plants. During periods of drought, especially, the larvae attack the living roots.

More recently, I have experienced considerable difficulty from these flies attacking the roots of other greenhouse plants. Maidenhair ferns were badly injured. Seedlings of some flowering plants are often almost a complete failure because of the ravages of the maggots. This, I find, is particularly true with pansies grown in "flats." Usually the seeds germinate and give promise of a fine stand; then, in a few days, all the plants wither and die. Digging in the soil discloses the myriads of Sciara maggots. The adult flies are usually also much in evidence, hovering around the boxes.

CONTROL MEASURES

Possibly we can make use of what we know of the feeding habits of the larvae of these flies. And again their relation to soil moisture is also an important consideration.

I tried placing rotting stable manure on the surface of the soil in one root cage. The flies from all over the greenhouse came to that cage. Soon the manure was full of maggots, yet none of them attacked the roots. The larvae were evidently quite satisfied with the manure, as long as it was kept moist. On the other hand, when I tried drought conditions, reducing the moisture so that the soil became quite dry, the maggots left the manure and became destructive to the roots.

Unfortunately we are unable to control the moisture supply in our pineapple fields. We grow a heavy stand of grass, or leave the refuse from the pineapples in the soil, all breeding and accumulating these pests. When, perchance, dry weather comes on, the damage is done. In the natural course of growth, these creatures must have their supply of moisture to survive. They turn to living roots as the only available supply of water, and the plants are required to meet a double drain—both drought and loss of roots.

The above observations suggest a cure. Could we not bait the pest? We may be able to treat the decomposing substances with poison, if we can find a chemical that does not act as too much of a deterrent to the feeding larvae. Another consideration, too, is the effect of this poison upon other decomposing organisms, such as fungi, bacteria, etc.

Again, as I have suggested, burning the plant refuse during drought conditions, gives the pests a serious setback. Piles of old stumps and refuse when filled with the larvae may be burned with advantage. It should be noted, however, that firing would be of little avail after the material has become dry. In that case all the creatures have left it and gone into the soil.

Finally, my experiments in the laboratory showed that the maggots are very susceptible to either of the extremes of moisture. Too much water kills them as quickly as too little. This fact could be made use of where flooding is practical. I used this method successfully in the greenhouse, and found that by adding an extract of pyrethrum the flies avoided the treated soil.